



# CLEAN COAL TODAY

A NEWSLETTER ABOUT INNOVATIVE TECHNOLOGIES FOR COAL UTILIZATION

## NEWS BYTES

In December, the **JEA ACFB Clean Coal Project** began testing in preparation for commercial startup in mid-2002. This effort will be followed by a two-year jointly funded demonstration period. JEA has successfully lit startup burners at Unit 2 of the Northside Generating Station in Jacksonville, Florida. These burners are important in drying and curing the refractory material lining the unit's walls. The company anticipated test firing Pittsburgh No. 8 coal some time in January. In November 2001, JEA received its first coal shipment (some 19,000 tons) which it transported via a new covered conveying system to a storage dome. After Unit 2 goes on line, JEA

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## CLEAN COAL AND POWER CONFERENCE EXPLORES COAL'S FUTURE



*DOE's Deputy Secretary Francis Blake addressed the Clean Coal and Power Conference plenary session*

The U.S. Department of Energy (DOE) Office of Fossil Energy (FE) Clean Coal and Power Conference, held in Washington, D.C. on November 19–20, 2001, had important messages to share regarding the role of coal in the post-September 11<sup>th</sup> world. Coal can provide domestic energy security based on abundant coal supplies, and is key to electrification in developing countries where economic progress could be expected to promote social and political stability. Attendees stressed the dangers of over-reliance on natural gas, and the importance of coal in the fuel mix.

They emphasized coal's continually improving environmental performance, its role as an energy price stabilizer and vital baseload fuel, and were optimistic about its prospects. The Conference, formerly called the Clean Coal Conference, was once again co-sponsored by the U.S. DOE, Center for Energy and Economic Development, National Mining Association, Electric Power Research Institute, and Council of Industrial Boiler Owners.

The importance of the conference was evident by the presence of high ranking DOE officials, such as Deputy Secretary Francis Blake, and Acting FE Assistant Secretary Robert Kripowicz, as well as prominent industry figures. Attendance was near 300 with representatives from industry, government, academia, and the research community. In his introductory remarks, Kripowicz traced the evolution of the government role from full funding of the Synthetic Fuels Corporation, to acceptance of the cost-share principle with private funding often exceeding the government share. He noted that President Bush's stated commitment to clean coal technologies will be based on a solid track record of achievements under the Clean Coal Program. Kripowicz believes that future RD&D in coal technology will produce even more advanced pollution controls capable of removing mercury and ultra-fine particles and other criteria pollutants; carbon dioxide sequestration integral to the overall energy cycle; and develop liquid fuels technologies producing value added products.

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*...Conference continued*

Reflecting on the current government role, attendees remarked that this Administration has shown an encouraging broad-based approach to energy policy, placing coal in the forefront. The investment strategy of today's FE program relies on R&D in enabling technologies, demonstration projects, and market penetration. Conference participants heralded FE's latest programs — the Power Plant Improvement Initiative, under which 8 projects with a total value of some \$110 million now are being negotiated; and the Clean Coal Power Initiative, a 10-year \$2 billion program designed to develop and demonstrate clean coal technologies for the utility industry. Coupled with this, continued advances are being made in the Vision 21 research program. This program seeks to achieve near-zero emissions from coal technologies by 2015. Carbon sequestration would be an important part of that effort.

John Derrick, CEO of PEPCO and Vice Chairman of the World Energy Council, gave the keynote speech. He noted that 2 billion people worldwide lack access to commercial energy. Foreign assistance efforts, he said, need to be reviewed in light of the terrorist attacks. Current efforts "...laudable as they may be, will be dysfunctional in a region that lacks

access to energy." Energy and trade drive economic development, and a "Marshall Plan" is needed to transfer energy technology to poor countries. This view was shared by General Richard Lawson, former head of the National Mining Association, who spoke of energy from coal as being "on the front lines of the second phase of the war against terrorism."

Over-reliance on natural gas was seen as being a shortsighted policy due to price volatility of gas and concerns about resource availability as use increases. Efforts should be focused on achieving a balance in fuels utilization, with natural gas being most suitable for peak capacity, and for direct uses such as heating and special high-temperature industrial processes. Participants cited coal's lower fuel cost, plentiful supply, and suitability as a baseload fuel when compared to natural gas. As Jacob Williams, a Vice President at Peabody Energy, pointed out, the average capacity factor of coal-fired power plants is now over 70 percent, which suggests that in five years there will be little added power available from existing units. This observation is of specific importance, considering the National Energy Policy estimates that 200,000 new megawatts of capacity (from all fuels) will be needed to take us through 2010, and another 193,000 through

2020. A speaker from DOE noted that a tracking effort at NETL identified 75 proposed new coal-fired power plants, totaling 25 GW, indicating that coal is already helping to meet this need.

Speakers also cautioned that price volatility can be just as harmful as price increases. Here coal can act as a stabilizer. Mark Whinton, a Vice President at the National Association of Manufacturers (NAM), pointed out that electricity is one of the largest cost components for some manufacturers. Natural gas prices of over \$7/MMBtu recently have put NAM members out of work. NAM supports a slowing rate of increase in natural gas use. Anthony Chan, Managing Director and Chief Economist at Banc One, represented a view from the investment community, and emphasized coal's price stability. He pointed out that one reason for the current economic downturn has been the large price increases for natural gas (41.8 percent in 2000) and oil products. At the same time coal prices have risen very little. Other speakers explored price differentials and cited a DOE study wherein coal costs of \$2.50/MMBtu less than natural gas, over time, would make it a more attractive purchase, even considering coal's higher capital costs for coal-fired plants.



FE's William Fernald, James Longanbach, and Ed Schmetz confer by the Ultra-Clean Fuels exhibit



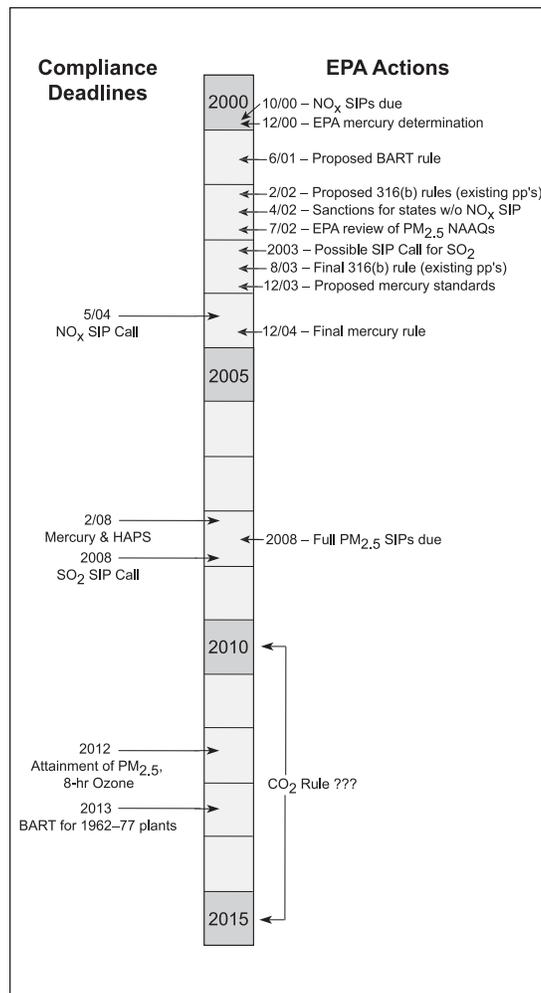
Jay Willer and Francis Lau of the Institute of Gas Technology along with FE's Lowell Miller

Jacob Williams noted that siting a mine mouth plant can make coal even more competitive. In this context, Peabody's new subcritical plant will use coal costing only 60 to 70 cents per MMBtu because it is mine mouth, saving rail transportation costs of \$0.35 to \$0.50/ MMBtu. Regardless of pricing issues and market variations, Jack N. Gerard, President & CEO of the National Mining Association, reminded the audience that since the energy crisis of the 1970s coal "...has been the mainstay of growth, diversity, and reliability in America's power supply." Almost 60 percent of growth since that time has come from coal.

Conference participants agreed that streamlining the regulatory process to eliminate uncertainties could greatly enhance coal's prospects. Particularly noted were new regulatory interpretations about plant modifications that can keep many plants in a perpetual state of New Source Review. Multi-pollutant legislation ("3 P" for controls of SO<sub>2</sub>, NO<sub>x</sub>, and mercury) proposed in the National Energy Policy is considered a potential remedy in streamlining the current system of multiple programs controlling the same pollutant, but with varying deadlines and permitting increments (see graph, above right). Overlapping rules, plus court challenges have hindered utility

decisionmaking to the point that needed plants may not be built.

Bill Brownell, an environmental attorney and Partner with Hunton & Williams, highlighted complexities in developing any multi-pollutant program and expressed concern over proposals in Congress that would simply add a cap and trade program, as another layer to the Clean Air Act with no effort to consolidate or streamline what is already there. He contrasted the policies of the 1970's where "more is better" and "command and control" prevailed, to the market incentives approach of the Title IV acid rain trading program. This program has achieved the targeted reductions at lower cost and before the mandated deadline. According to Brownell, development of multi-pollutant legislation involves a number of problematic issues such as: integration with the existing Clean Air Act; role of states that currently are delegated the authority to run the program and to establish State Implementation Plans; characteristics of



the incentive or allocation program; and nature of the accounting system.

Over the two-day conference, the presentations made clear that coal does indeed have a role in our national and global energy mix, both now and in years to come.



Clean Coal Program participant CQ Inc., joined the Clean Coal and Power conference



Office of Coal & Power Systems exhibit highlights DOE's Vision 21 concept

## MEMBRANE IMPROVEMENTS SUPPORT GAS SEPARATION

Efficient gas separation in support of gasification-based systems is an important enabling technology to help achieve the U.S. Department of Energy, Office of Fossil Energy (FE) Vision 21 goals — power from coal with near-zero emissions, coupled with CO<sub>2</sub> sequestration. New processes using membranes to separate oxygen from air, and hydrogen from the coal gas stream, offer potential for increased efficiencies and lower cost. Hydrogen from gasification-derived syngas can be used as both a clean fuel and processing agent. These membranes typically are made of ceramics (metal oxides) or ceramic-metallic composites (cermets), which include catalytic materials designed to enhance reactivity. Separating out hydrogen leaves CO and CO<sub>2</sub> in the remaining gas stream. The CO can be readily converted to CO<sub>2</sub>, making possible more efficient CO<sub>2</sub> sequestration. Gas separation enables a wide variety of feedstocks (including coal, biomass, and wastes) to be converted into clean fuels and chemicals and linked to inherently efficient power generation technologies, such as fuel cells. Present methods for separating out these gases from process streams are largely energy-intensive and inefficient. The challenge facing researchers lies in identifying materials that can withstand high-temperature and -pressure corrosive environments, and at the same time be able to process high volumes of syngas. Ceramic and ceramic-metallic materials used to date have problems with durability of sealing components, and with thermal expansion that can cause damaging material stress.

### OXYGEN SEPARATION

Current methods of oxygen separation are high-capital-cost, energy-intensive cryogenic processes. One membrane-based process being studied as part of the FE National Energy Technology Laboratory (NETL) R&D program involves a novel class of materials known as Ion Transport Membranes (ITM) as a means to separate oxygen from air at high temperatures and pressures. These membranes offer the potential to separate oxygen from air at far higher efficiencies and less cost — more than one-third lower than conventional technologies. Because oxygen transport membranes operate at high temperature, they are ideally suited for integration with integrated gasification combined-cycle (IGCC) plants.

NETL is involved in a three-phase technology partnership with Air Products and Chemicals, Inc. to develop, scale up, and demonstrate the ITM technology to be integrated in an IGCC facility. Aside from lower capital cost advantages, integration of ITMs could improve efficiency, lower costs of electricity, and offer superior environmental performance. In Phase I, an Air Products-led team achieved the cost and performance targets for commercial operations, allowing scale up to a 0.1-ton-per-day (TPD) technology development unit, with an estimated 30–45 percent reduction in capital costs. A newly developed thin-film membrane structure exceeded production targets by 25 percent over 2,300 hours of operation. Phase II will scale up the ITM technology to a roughly 5-TPD sub-scale engineering prototype facility. In Phase III, a demonstration facility will be built of about 25 TPD; critical materials needed for technology assessment will be obtained; membrane fabrication initiated; and operating, performance, and economic data needed for technology commercialization will be gathered. Commercialization is expected in 2008.

The Air Products team also completed a study of IGCC economics comparing the use of ITM to a state-of-the-art cryogenic air separation unit (ASU). The estimated economic benefits of ITMs for the IGCC application are a 7 percent reduction in overall plant installed capital cost, a 7 percent improvement in power output, a 35 percent savings in the installed specific cost of the air separation unit compared to the cryogenic ASU, a 37 percent improvement in the power requirement of the oxygen plant, and a 2.2 percent improvement in the overall power plant efficiency.

In another oxygen separation effort, NETL has a multi-phase research and development agreement with Praxair, Inc. to develop ceramic oxygen separation membranes that meet cost and performance goals similar to those set for the Air Products team. Praxair is developing a class of Oxygen Transport Membranes (OTM) that also are capable of separating oxygen from air at high temperature and pressure.

Praxair has made significant progress toward demonstrating the commercial viability of their OTM, achieving product purity and manufacturing targets. The goal of achieving 75 percent of commercial target production has been achieved in a laboratory reactor under conditions similar to IGCC operation. In addition, a high-temperature seal has been developed that allows oxygen to be produced at the commercial target of greater than 95 percent oxygen purity. These targets have been achieved under stable operating conditions at a pressure differential of 250 pounds per square inch. Praxair has also demonstrated manufacturing capability to fabricate composite membrane tubes of the pre-commercial length to be tested in their multi-tube, pilot-scale reactor. The design

and construction of this reactor has been completed, and its operation over the next fiscal year will validate operation of OTM systems and provide information for further scale up.

## HYDROGEN SEPARATION

Currently there are no effective hydrogen separation processes in use. To develop this needed new technology, NETL is partnering with Eltron Research Inc. and ITN Energy Systems, Inc. to develop advanced hydrogen separation membranes based on a Proton Transport Membrane (PTM) concept. The objectives of both projects include: discovery of new hydrogen separation materials; the design, construction, and testing of prototype hydrogen separation devices; and generation of data needed for economic assessments.

Eltron is developing membranes of perovskite composition. Eltron has successfully prepared thin-film perovskites, 100 millionths of a meter (microns) thick, and composite materials with distinct ceramic and metallic phases. The objective is to demonstrate commercially relevant hydrogen permeate flux using these thin-film membrane structures. Operations of ceramic hydrogen separation membranes at high temperature and pressure require chemically resistant seals with similar mechanical and expansion characteristics as the membrane material. Eltron has developed such a seal, and is developing porous platinum and nickel catalysts for improving membrane surface exchange reactions.

In another project, ITN Energy Systems will develop composite, functionally graded, hydrogen separation membrane modules for application to coal gasification processes, and eventually to other Vision 21 fossil fuel plants. These composites also will serve as functionally graded,

porous catalyst layers, thereby enhancing the hydrogen transport rates across the membrane. The objective of the ITN project is to demonstrate commercially significant hydrogen flux rates approximating 50 ml/min-cm<sup>2</sup> in a laboratory-scale prototype in the 600–900 °C temperature range using novel hydrogen separation membranes in the thickness range of 50–400 microns.

Research also is proceeding at DOE facilities in collaboration with private partners. NETL's Office of Science & Technology is conducting hydrogen separation membrane research at its own unique high-pressure, high-temperature Hydrogen Membrane Test units. These units can operate with hydrogen gas mixtures, including impurities such as H<sub>2</sub>S, at the severe conditions found in gasification streams (up to 900 °C and 400 psi). Efforts to date have focused on determining the permeability characteristics of membrane materials at these operating conditions, and have included bulk metals such as palladium and tantalum, palladium-coated metals, and metal/ceramic composites.

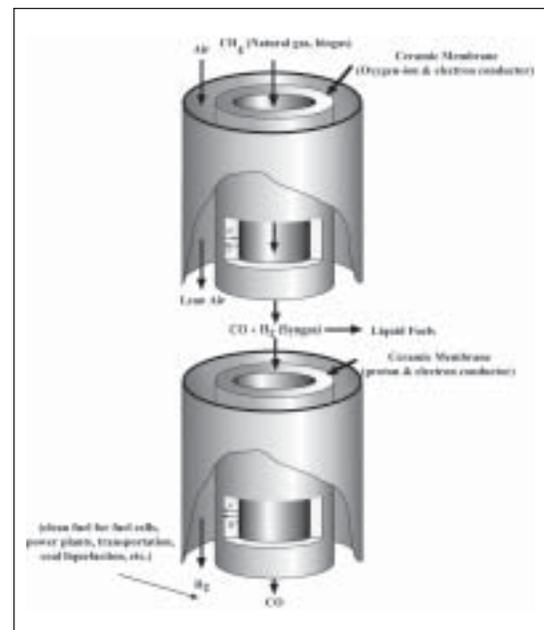
Researchers at Argonne National Laboratory are attempting to set up a module for the generation of hydrogen in a combined process of partial oxidation and hydrogen extraction, as illustrated in the figure (right). This innovative design uses recent advances in the development of OTMs for the production of syngas from methane and PTMs for the production of hydrogen from syngas.

Gas separation research in support of gasification technologies is also leveraging discoveries at Oak

Ridge and Los Alamos National Laboratories. Using extensive membrane technology that has been developed over the past 40 years in nuclear gaseous diffusion, researchers at the K-25 Site in Oak Ridge, currently managed by Bechtel-Jacobs Company, have synthesized a high-temperature porous membrane based on alumina for the separation of hydrogen from the product stream of a coal gasifier. In recent months, a process has been discovered whereby the membranes can be fabricated routinely with essentially no defects.

Los Alamos National Laboratory researchers have demonstrated that a catalytic membrane reactor based on a palladium alloy is an effective means to recover tritium from an exhaust stream diluted by water and methane. The reactor is now being adapted for fossil energy needs in a licensing arrangement with GenereX, Inc. of Tryon, North Carolina.

Membrane improvements thus far, achieved through the FE program and elsewhere, are helping to develop materials vital to achieving the goals of Vision 21.



*Ceramic membranes are used for clean fuel production*

## ONGOING RESEARCH UPDATES $PM_{2.5}$ SOURCE FINGERPRINTS

Recent testing in the U.S. DOE National Energy Technology Laboratory (NETL) pilot-scale Combustion and Environmental Research Facility (CERF) has been focused on  $PM_{2.5}$  dilution sampling “source fingerprinting.” Studies being conducted by researchers at Carnegie Mellon University (CMU) and the University of Maryland (UM) rely on unique single-particle characterization instrumentation to support the Office of Fossil Energy’s University Coal Research, and Innovations and Existing Plants programs. This experimental data will help researchers better determine the origin and mechanisms that lead to primary (part of the coal fuel) and secondary  $PM_{2.5}$  (particles formed during burning, cooling, and mixing), and the destination of  $PM_{2.5}$  emissions after they leave the stack. Models could more accurately be used to evaluate regulatory policies and aid in technology development. The important fingerprinting work, updating data almost 20 years old, will tie together the extensive ambient air quality and modeling efforts undertaken by NETL and EPA.

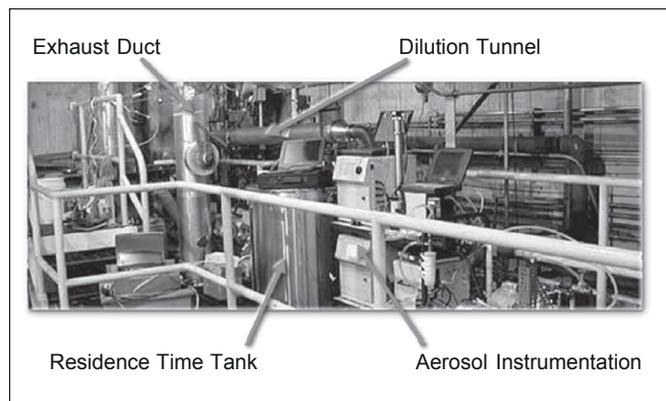
The main objectives of the fingerprinting effort are to characterize the emissions of primary  $PM_{2.5}$  from coal-fired utility boilers, study the formation of fine organic aerosols from these sources, and quantify sampling artifacts due to water and vaporization/condensation of semivolatile compounds. Researchers seek to characterize these particles and determine their origin, including their precursor species. When coupled with advanced models, this characterization theoretically will allow  $PM_{2.5}$  emissions to be tracked from their sources — in this case, coal-fired boilers — to their eventual destinations. Characterization could determine whether particles came from a coal-fired power plant, a steel plant, or a home fireplace.

An important method of updating the fingerprints is a dilution sampler now being developed. The sampler, located at the stack, simulates mixing, aerosol condensation, reactions, and other transformations that occur downstream of the stack plume. Traditional exhaust stack sampling methods rely on heated sample filters, while the dilution sampler allows the investigation of processes such as nucleation, condensation, and coagulation, which affect the size distribution and composition of the emissions. To aid in the research, UM also has introduced a novel adaptation of laser-induced breakdown spectroscopy, a technology based on earlier research at Sandia and Livermore National Laboratories. The technique allows simultaneous single-particle characterization for 15 different metals.

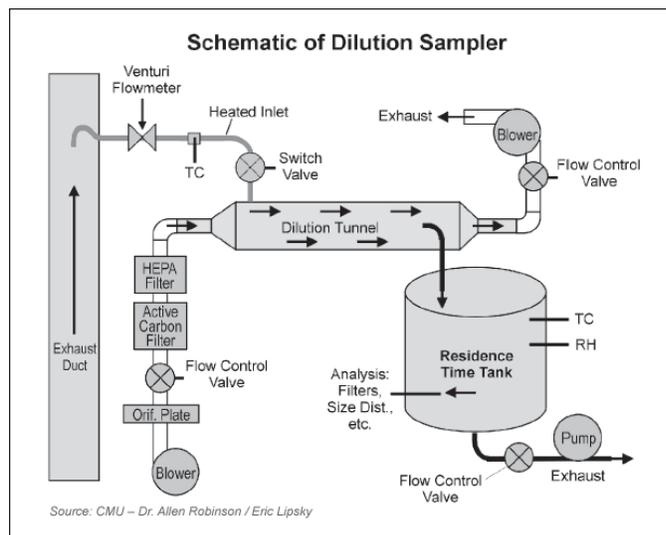
Additional tests are being planned under this project, with the dilution sampler at the CERF, to further investigate the effects of coagulation, as well as the differences between dilution sampling and direct-stack sampling on

concentrations of trace species. After the effects of the various sampling parameters have been investigated, the sampler could be used to perform detailed sampling on full-scale coal boilers and other major industrial point sources.

Fingerprinting research will provide scientifically objective and peer reviewed data to assess the contributions of coal-fired utilities to primary and secondary ambient air  $PM_{2.5}$ . This research will supplement



*The dilution sampler at NETL's Combustion and Environmental Research Facility*



data collected by the nationwide EPA monitoring network and Supersites, with collaboration from state and county governments, private sector consortia, and universities. The NETL will help provide

data to guide any adjustment of National Ambient Air Quality Standards (NAAQS) by the U.S. EPA, and subsequent development of State Implementation Plans (SIPs) by state regulators during 2002–2008 for regions that are not in compliance with the new NAAQS-PM<sub>2.5</sub> 24-hr average limits of 65 µg/m<sup>3</sup> and an annual mean limit of 15 µg/m<sup>3</sup>. For states that are required to submit implementation plans by 2008, the research will also be helpful in providing data on interrelationships of PM<sub>2.5</sub> with NO<sub>x</sub>, SO<sub>2</sub>, NH<sub>3</sub> slip, unburned carbon, mercury, and other HAPs, all of which influence technology choices for coal-fired utilities.

To complement PM<sub>2.5</sub> dilution sampling studies, NETL researchers acquire mercury speciation emissions data, as well as detailed furnace sampling characterization of temperature, gas composition, and particle burn-out profiles. After the CERF test program is completed, CMU, UM, and other researchers will conduct field work using the novel dilution sampling equipment to update “source fingerprints” for coal-fired utilities, steel and coke plants, other industries, and transportation vehicles.

## CLEAN COAL TODAY

### *Published quarterly by:*

The Office of Fossil Energy  
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Washington, DC 20585

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## PROGRESS UNDER TWO CLEAN COAL FUNDING VEHICLES

The Fiscal Year 2002 appropriations bill for the Department of Interior and Related Agencies provides \$150 million in federal matching funds for the Clean Coal Power Initiative (CCPI), part of the 10-year, \$2 billion effort in clean coal technology development and demonstration pledged by President George W. Bush and recommended in his National Energy Policy. A limited number of joint government-industry funded projects could provide early demonstration opportunities for coal and power RD&D as a precursor to Vision 21 facilities, near-zero pollutant plants now under development as part of Fossil Energy’s R&D program. DOE has sought stakeholder input through public meetings (September 28 and November 20, 2001, and January 17, 2002). A draft solicitation was issued December 21, 2001, with comments due by January 23, 2002. The congressional directive is for “demonstrations of commercial scale technology to reduce the barriers to continued and expanded coal use” and to “demonstrate technologies that can strengthen electricity reliability ...in an environmentally acceptable manner.” Round 1 of the CCPI seeks projects that demonstrate advanced coal-based technologies with subsequent accelerated deployment of these technologies to commercial use. CCPI projects would be categorized as clean coal technology projects and therefore exempted from New Source Review. As DOE indicated at the public meetings, it hopes to receive an advance appropriation so that \$300-400 million could be awarded, likely for a limited number of large projects that focus on modernizing the existing fleet of aging power plants. The solicitation is scheduled for release on or about February 18, 2002. For the latest updates, see <http://www.netl.doe.gov/coalpower/ccpi/>.

Under the Power Plant Improvement Initiative (PPII), a precursor program, eight projects were selected last October with a total value of \$110 million. The government expects to provide some \$51 million for cofunding project costs. The PPII was funded in fiscal year 2001 with \$95 million redirected from the Clean Coal Technology Demonstration Program, and has the objective of improving performance of existing or new coal-fired electric plants. Many of the projects involve lower cost technologies for reducing pollution, while others would improve power plant performance and reliability. Abstracts of the projects are available on the Fossil Energy web page ([http://www.fe.doe.gov/techline/tl\\_ppii\\_sel.shtml](http://www.fe.doe.gov/techline/tl_ppii_sel.shtml)).

Additional funding of \$3.3 billion over 10 years would be provided under H.R. 4, Securing America’s Future Energy Act, the Administration’s energy proposals as passed by the House of Representatives. Section 3117 of H.R. 4 would provide financial and other incentives for investing in qualifying, advanced clean coal facilities. As mentioned at the CCPI workshops, DOE would recommend a diverse set of financial incentives to complement, and not duplicate, the CCPI.



## INTERNATIONAL INITIATIVES

### NEW APEC REPORT ON CO<sub>2</sub> REDUCTION OPTIONS

A new report entitled “Options to Reduce Carbon Dioxide Emissions from Electricity Generation in the APEC Region” has been completed by Levelton Engineering Ltd of Richmond, B.C., Canada, and Malaysian Environmental Services of Johor Bahru, Malaysia. This study was prepared for the Expert’s Group on Clean Fossil Energy under the Asia Pacific Economic Cooperation’s (APEC) Energy Working Group. The Expert’s Group is co-chaired by Fossil Energy’s Dr. Sun Chun and Scott Smouse. The study was undertaken to help APEC member economies address greenhouse gas emissions from existing and future fossil-fueled power generating facilities. The study objectives were to develop data on current CO<sub>2</sub> emissions from the electricity generating sector, and possible emission reduction measures.

Fossil fuel-fired powerplants in the APEC region generate 42 percent of the region’s total CO<sub>2</sub> emissions from fuel combustion, and almost 25 percent of CO<sub>2</sub> emissions generated worldwide. Forty three percent of the APEC region’s electricity generation comes from coal, and electricity demand is expected to grow 2.8 percent per year over 1999–2020, according to DOE’s Energy Information Administration. Thus, the APEC region will likely be a growing contributor to worldwide greenhouse gas emissions.

The study just released evaluates the potential to reduce CO<sub>2</sub> emissions from existing coal-, oil-, and gas-fired generating facilities in the region by considering a total of 19 different scenarios, including repowering and plant replacement. Improvements in power plants using pulverized coal and co-firing coal and natural gas in pulverized coal subcritical plants showed the potential for significant reductions in CO<sub>2</sub> emissions. All repowering options studied were attractive in terms of CO<sub>2</sub> reduction, but depended upon site-specific economic feasibility, availability of capital funds, and fuel access. The study also notes that CO<sub>2</sub> reduction would result in co-benefits of reductions in emissions of particulate matter, NO<sub>x</sub>, SO<sub>x</sub>, CO, VOCs, and hazardous air pollutants. While the study did not consider the cost effectiveness of the various options, it identifies the approaches that are likely to yield the greatest emissions reductions.

The new report will soon be available on the Expert’s Group web site (<http://www.apec-egcfe.fossil.energy.gov>). A request for proposals (RFP) is being prepared for Phase II of the project, which will present case studies of cleaner, more efficient power generating facilities and develop action plans for at least two developing APEC economies. Interested parties should contact: [scott.smouse@netl.doe.gov](mailto:scott.smouse@netl.doe.gov).

### ICCR MEETING DISCUSSES MEMBER ENERGY PLANS

FE representatives participated in the 26<sup>th</sup> meeting of the International Committee on Coal Research (ICCR) which took place in October in Strasbourg, France. The committee meets annually to determine the current status of coal R&D activities, and to identify promising areas for research collaboration. ICCR was formed in 1973 in response to the oil crisis. Fourteen countries involved in coal R&D are members.

Each delegation at ICCR is given the opportunity to suggest R&D areas. This year, the U.S. delegation proposed use of DOE’s Power Systems Development Facility, in Wilsonville, Alabama, to sponsor



international tests of instruments and sensors for measuring particulate loading. Under the proposal, PSDF, would also host an on-site workshop, with a panel of ICCR experts, on computational fluid dynamics and operational issues related to gas filtration.

A number of country reports were presented at the meeting. The shift to a hydrogen economy was seen to be important, and is part of the longer term plans of New Zealand and Japan. New Zealand is looking into hydrogen from coal, and secondarily other fossil fuels and waste streams, with an initial focus on hydrogen of sufficient quality to be used in fuel cells, microturbines and other engines. Research would involve identifying the potential for hydrogen as a transportation fuel, resolving infrastructure and gas storage issues, perfecting fuel cell technology and developing distributed generation models. Increased use of hydrogen is seen as a way to reduce greenhouse gas emissions. In New Zealand, industry is required to negotiate Greenhouse Gas Agreements with the government to achieve specific emissions reductions. If these are not effective, a representative from New Zealand indicated that the country would impose carbon taxes.

Japan has a four-phase energy strategy, with the last phase (2020–30) assumed to be a zero-emission, hydrogen era based on coal. Japan's report noted that it sees promise in DME synthesis technology as a source of clean hydrogen from coal. Another method noted would produce hydrogen via a reaction between coal and supercritical water.

The 2002 meeting of the ICCR is scheduled for Brisbane, Australia. An associated conference, the International Conference on Coal Research, meets every three years. The previous conference was held in South Africa and the next conference is scheduled for 2003 in the People's Republic of China.

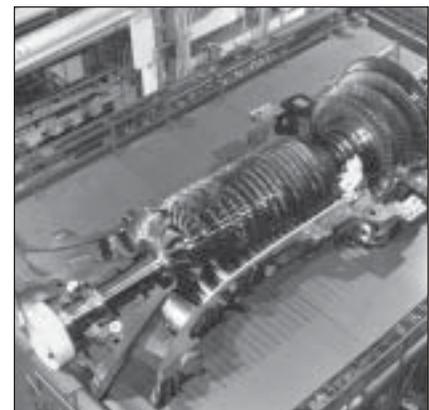
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will take older, more polluting oil and gas units out of service. DOE is providing \$74 million in cost-shared support for this 300-MWe advanced circulating fluidized-bed (ACFB) combustion project, which is expected to provide important environmental, economic, and technical performance data for future ACFB units.

Public meetings on the draft environmental impact statement (EIS) for the **Kentucky Pioneer IGCC CCT Project** were held December 10 and 11, 2001, in Lexington and Trapp, Kentucky. The meetings were well attended. Most of the project-specific comments centered around the use of refuse-derived fuel. The comment period was extended to January 25, 2002. The 400-MWe Pioneer project would demonstrate co-firing a blend of high-sulfur bituminous coal and municipal solid waste in an oxygen-blown, fixed bed slagging gasifier. A 2-MWe molten

carbonate fuel cell, powered by coal gas, would also be part of the system. Concerns of the public will be addressed in the final EIS, which is scheduled for release in early Spring.

The General Electric (GE) H System™ turbine, developed under the **DOE Fossil Energy Advanced Turbine System Program**, has registered its third commercial sale, to Tokyo Electric for use at its Futtsu Thermal Power Station Group No. 4 project. The total output of the three combined-cycle systems being sold by GE is 1,520 MWe. The GE H System™ is the first gas turbine combined-cycle in the world to reach 60 percent thermal efficiency. While currently fueled by natural gas, such turbines could eventually be fueled by syngas from coal. The Tokyo Electric 9H turbine will be ready for shipment in early 2006, with commercial operation expected to begin mid-2008. The first 9H has already been shipped to the Baglan Bay Power Station in South Wales, United



*General Electric's H System™ turbine*

Kingdom, and is scheduled for startup in the summer of 2002. Another GE turbine, the 7H, is scheduled to enter service in 2004 at the Heritage Station in Scriba, New York. In another important development, the Turbine Program at FE's National Energy Technology Laboratory received its sixth "Powerplant of the Year" award in early December 2001 at the Power-Gen Conference held in Las Vegas, Nevada.

## NETL HOSTS VIRTUAL SIMULATION WORKSHOP

On September 11 and 12, 2001, the DOE National Energy Technology Laboratory (NETL) held the first of a series of workshops to facilitate development of the virtual simulation component of Vision 21. Approximately 40 stakeholders participated, including representatives from National Laboratories, academia, government, and industry.

One of the primary goals of Vision 21 is to effectively remove all environmental concerns associated with the use of fossil fuels for producing electricity, transportation fuels, and high-value chemicals. The virtual simulation component of Vision 21 brings the growing power of high-performance computing and visualization technology to that effort. While modeling tools for specific applications are available, models capable of providing detailed information about the operation of complex energy systems have not yet been developed. The participants examined modeling needs from a technology specific basis — fuel/gas stream processing, electricity from syngas, fuels/chemicals from syngas, and process simulation — as well as more generically. They looked at modeling requirements from the broad system perspective to the more narrow plant, component, and sub-component levels. Participants noted that models for Vision 21 technologies must provide accurate solutions quickly; be flexible, robust, and easy to use; and incorporate a visual interface.

From the system and plant perspective, workshop participants stressed the need for dynamic process simulators specific to Vision 21 plant issues, such as cost and economics, technical risk, operator training, and energy and mass transport. These models are envisioned as nexuses into which lower-level models link. They would be process models accessible through an advanced visualization interface that is interactive and can mimic plant operations, but would not be considered repositories for all plant data.

Component models were seen as optimization tools; they need to be based on fundamental chemistry and physics, and be capable of handling transient, or time-varying, properties. Workshop participants specifically mentioned developing component models that simulate fuel cells, turbines, slurry bubble-column reactors, wax-upgrading reactors, gasifiers, and combustors. The models would be able to help with start up, shut down, upsets, and control, as well as normal operation and design. The sub-component models, in turn, need to address combustion stability and burner behavior, blade cooling, fuel injection, phase equilibrium, catalyst selectivity, heat and mass transfer, pollutant concentrations in the parts-per-billion range, turbulence, and the physics and chemistry of mineral matter, gas, and char.

The participants noted the need for model validation data at all levels of detail. Specifically cited was the need for improved data at the sub-component level. Also cited was the need for a cycle of information exchange and feedback among model developers, technology developers, and technology applicers, in spite of the difficulty in sharing proprietary information.

In terms of federal government activities, participants saw the government as having an important role in fundamental data collection and model development through its own in-house activities, as well as through univer-



sity and SBIR contracts. They noted NETL's efforts in the Computational Energy Science Focus area and specifically the virtual environment center under construction at NETL's Morgantown campus (see Summer 2001 *Clean Coal Today*). That facility is expected to be accessible to outside researchers. In addition to workshops and conferences, the government could facilitate information exchange by requiring it in Requests for Proposals. Standardization in model inputs and outputs would be another useful practice. Overlapping stakeholder steering groups could guide the development of models for each component and system in Vision 21.

The development of accurate, flexible models based on an open architecture and using advanced visualization will speed the development of Vision 21, thus lowering costs. The models will be used early on to identify technology limits and verify economic viability. Linked with experiments, the models will guide and minimize their cost. They will be used to develop, evaluate, and explore alternative designs and operating conditions to identify control and stability issues and to minimize scale-up problems. Coupled with advanced visualization, the models will quickly provide technology developers with a keen understanding of a process, and will yield an intuitive feel of Vision 21 plant behavior for technology users.

## R&D MILESTONES

***Oil recovery bacteria “evolves” into coal cleaning.*** A microbe first developed in the Fossil Energy program in the 1980s to recover crude oil has been cultivated over the years into a bacteria that now shows promise as a way to clean pollutants from coal. The bacteria strains included newly evolved members of the species *Leptospirillum ferrooxidans* and *Thiobacillus ferrooxidans*, as well as a variety of mixed cultures. Scientists at Brookhaven National Laboratory received a patent recently for the process employing these bacteria that remove sulfur and heavy metal contaminants from coal. For more than a decade, the scientists have been gradually weaning the bacteria off of oil and forcing them to adapt to the harsher conditions of coal cleaning. The research paid off with bacteria that cleans coal at temperature conditions up to 185 °F, pressures up to 2,500 pounds per square inch, over wide ranges of pH and salinity, and in the presence of toxic metals.

***Testing is underway to develop E-Fuel, a biofuel candidate for co-firing with coal in commercial gasifiers and numerous industrial applications.*** Under contract with NETL, EnerTech Environmental is developing the E-Fuel Process by thermally treating municipal and sewage wastes. Successful parametric testing has been conducted in a Process Development Unit. Testing this past fall has focused on increased feed solids loading, lower operating pressure and temperature and improved solids dewatering in order to reduce costs while increasing throughput and heating value of the final pelletized product. Testing is expected to continue until mid-2002 at which time a 60 ton/day demonstration plant will be designed for a specific site.

***DOE spinoff leads to virtual turbine training.*** A spinoff of FE’s Advanced Turbine Program is a highly instrumented turbine that helps power the campus at Clemson University. The concept was developed by the South Carolina Institute for Energy Studies (SCIES) at Clemson, which coordinates FE’s Advanced Gas Turbine Systems Research Program, a consortium of 100 universities in 38 states. Now, with the turbine as the core, the University has created an Energy Systems Laboratory and has implemented new curricula focusing on state-of-the-art power plant operations. A unique aspect is that turbine data is posted in real time on the Internet, allowing for student analysis and computerized simulations. The Virtual Turbine lab is being backed by number of turbine and instrument manufacturers.

***NETL sponsors a successful workshop on terrestrial sequestration and mineland reclamation.*** The workshop, held November 6–7, 2001, in Lexington, Kentucky, brought coal and electric utilities together with government, academia, and organizations interested in offsetting CO<sub>2</sub> emissions by storing carbon in the vegetation and soils of degraded land. The workshop was co-sponsored with DOE’s Office of Science, and included participation from the U.S. Forest Service, the Office of Surface Mining, along with several universities and non-governmental organizations. The more than 50 invited attendees discussed current practices and incentives to increase the role of terrestrial sequestration in mineland reclamation, long-term implications of carbon management on the mining and electric utility industries, and public-private partnerships in terrestrial sequestration. Summary reports and plenary presentations can be viewed at [www.netl.doe.gov/coalpower/sequestration](http://www.netl.doe.gov/coalpower/sequestration).

***New research in supercritical coal plants is expected to improve the competitive position of U.S. boiler manufacturers.*** NETL will provide \$10.5 million to The Energy Industries of Ohio, Inc., which will head a consortium of boiler manufacturers, the Electric Power Research Institute, the Ohio Coal Development Office, and DOE’s Oak Ridge National Laboratory to study new materials, alloys, and other advances to make possible the domestic development of high-efficiency supercritical plants. A major goal of the consortium effort is to develop pipes and components made of advanced steel that are capable of withstanding operating temperatures of 1,400 °F. The project will build on work initiated in Europe and Japan over the past 15 years, where high coal prices have spurred development of high-efficiency supercritical plants operating at 1,300 °F, with state-of-the-art flue gas cleanup systems. Foreign manufacturers may provide candidate materials for testing, and stand to gain from this leveraged research effort that could raise operating temperatures of supercritical systems to 1,400 °F and 1,600 °F. The consortium will provide \$4.8 million toward the effort.

## STATE INITIATIVES

### WISCONSIN PLAN EMPHASIZES FUEL DIVERSITY

Speaking at the Office of Fossil Energy's Clean Coal and Power Conference this November, Richard Abdo, Chairman and CEO of Wisconsin Energy Corporation, outlined the "Power for the Future" initiative devised by Wisconsin Energy and a broad-based customer stakeholder group in Wisconsin, Customers First! Coalition. The 10-year plan is designed to provide reliable and affordable power from diverse energy sources, while having a net positive effect on environmental quality. The company views the initiative as a potential model for other states.

Wisconsin generates 61 percent of its electricity from coal, but more than half the fleet is at least 30 years old. No new coal plants have been permitted since the early 1980s. Abdo noted a tendency to go for quick-to-build, politically easy-to-site natural gas plants, but "...the quick solution may not be the best one." Thus, the company and its stakeholder groups took stock of the longer-term view in development of the Power for the Future Initiative. While Abdo does not underestimate the challenges in attaining Public Service Commission of Wisconsin (PSCW) approval and permitting, he is optimistic that final approval will be granted in late 2002. In October 2001, Wisconsin Energy received a positive limited Declaratory Ruling from the PSCW allowing it to proceed with advanced planning and early procurement activities.



*Wisconsin Electric-Wisconsin Gas's Oak Creek Power Plant on Lake Michigan, the location for three future coal generating units.*

The \$7 billion initiative would provide 2,800 MW of power through two 500-MW intermediate-load combined cycle gas units, two 600-MW supercritical units using pulverized coal, and one 600-MW plant using IGCC technology. The amount of renewable capacity would increase and the company would produce 50 percent more energy from renewable sources than what state law requires. This will increase renewable capacity from 127 MW to 400 MW over the next ten years. The distribution system would also be upgraded. The proposed IGCC plant would incorporate state-of-the-art selective catalytic reduction, flue gas desulfurization, fabric baghouses or electrostatic precipitators for particulate control, as well as mercury controls now under development in FE's program and elsewhere. IGCC would be the last of the plants to come on line, in about 2011. According to Abdo, supercritical as a first step will "...allow time for IGCC to become more dependable through technology improvement and direct experience in the utility industry." The preferred site for all the coal plants is the existing Oak Creek Power Plant, south of Milwaukee. Overall company portfolio emissions would be reduced by these clean technologies, as well as by modernizing and retiring older plants.

The initiative is premised on the principle that a sensible energy policy must leverage domestic resources and emphasize fuel diversity. Public acceptance of coal, upon which a good part of the plan depends, relies on the creation of informed consensus among a broad base of interests. "The consensus process transformed key interest groups from spectators and critics into owners, participants, and partners," Abdo said. An education campaign has been and continues to be an important part of this process. Abdo particularly noted a lack of public information about coal's spectacular environmental improvements in recent years, its cost advantage over natural gas, and the inefficiencies of using natural gas for non-direct uses because 70 percent of the energy is lost as waste heat.

Wisconsin Energy's intention is to submit, in February 2002, an application and detailed plan for power plant development, following review of the documents by Customers First! Each plant must receive a Certificate of Public Convenience and Necessity, as well as environmental permits.

## UPCOMING EVENTS



— February 25-27, 2002 —  
**Turbine Power Systems Conference and Condition Monitoring Workshop, along with Short Course on Gas Turbine Technology (February 28-March 1)**

Sponsors: NETL  
 Location: Galveston, TX  
 Contact: Kimberly Yavorsky  
 Phone: 412-386-6044  
 E-mail: [kimberly.yavorsky@netl.doe.gov](mailto:kimberly.yavorsky@netl.doe.gov)

— March 4-7, 2002 —  
**The Clearwater Conference – the 27<sup>th</sup> International Technical Conference on Coal Utilization & Fuel Systems**

Sponsors: Coal Technology Association working closely with ASME, DOE, and NETL  
 Location: Clearwater, Florida  
 Contact: Barbara Sakkestad  
 Phone: 301-294-6080  
 E-mail: [barbarasak@aol.com](mailto:barbarasak@aol.com)

— March 21-22, 2002 —  
**Third Annual Solid State Energy Conversion Alliance (SECA) Workshop**

Sponsors: PNNL & NETL  
 Location: Washington, DC  
 Contact: Kimberly Yavorsky  
 Phone: 412-386-6044  
 E-mail: [kimberly.yavorsky@netl.doe.gov](mailto:kimberly.yavorsky@netl.doe.gov)

— April 9-10, 2002 —  
**PM 2.5 and Electric Power Generation: Recent Findings and Implications**

Sponsors: DOE, NETL  
 Location: Pittsburgh, PA  
 Contact: Kimberly Yavorsky  
 Phone: 412-386-6044  
 E-mail: [kimberly.yavorsky@netl.doe.gov](mailto:kimberly.yavorsky@netl.doe.gov)

## CCT PROJECT MILESTONES

Project	Calendar Year	2000				2001				2002				2003				2004				2005				2006				2007			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4				
SCS — Wall-Fired		[Design & Construction]												Environmental Control Devices																			
Tampa Electric*		[Design & Construction]												Advanced Electric Power Generation																			
ADL — Coal Diesel		[Design & Construction]												[Operation]																			
JEA		[Design & Construction]												[Operation]																			
KY Pioneer Energy		[Design & Construction]												[Operation]																			
McIntosh 4A		[Design & Construction]				[Reporting]																											
McIntosh 4B		[Design & Construction]				[Reporting]																											
Western Syncoal*		[Design & Construction]												Coal Processing for Clean Fuels																			
Air Products — LPMEOH		[Design & Construction]												[Reporting]																			
ThermoChem*		[Design & Construction]				[Operation]				[Reporting]				Industrial Applications																			
CPICOR		[Design & Construction]																[Operation]															
*Operation Complete		[Design & Construction]				[Operation]				[Reporting]																							

## STATUS OF ACTIVE CCT DEMONSTRATION PROJECTS

### ENVIRONMENTAL CONTROL DEVICES

**Southern Company Services, Inc.** – *Demonstration of Advanced Combustion Techniques for a Wall-Fired Boiler.* All testing on the original project has been completed and reported. Phase 4 has been extended until March 31, 2002, to evaluate the use of GNOCIS and other computerized process control software to further optimize operation of Unit 4 by controlling additional processes, including ESPs, sootblowers and steam side equipment, at the plant. (Coosa, GA)

### ADVANCED ELECTRIC POWER GENERATION

**City of Lakeland, Department of Water & Electric Utilities** – *McIntosh Unit 4A PCFB Demonstration Project and McIntosh Unit 4B Topped PCFB Demonstration Project.* Lakeland Electric continues to evaluate its options to meet future power demand. During this internal review, Lakeland, Foster Wheeler, DOE, and others have been reviewing the system concept, siting, and financial issues in order to improve the project. (Lakeland, FL)

**JEA** – *ACFB Demonstration Project.* A Record of Decision under NEPA has been signed. Unit 2 achieved mechanical completion in July 2001, with first fire scheduled for November and commercial operation in mid-2002, to be followed by two years of demonstration. (Jacksonville, FL)

**Kentucky Pioneer Energy, L.L.C.** – *Kentucky Pioneer Energy Project.* The Draft EIS was issued in early November 2001 and the public meetings were held in December 2001. The public comment period ended

January 25, 2002. The final EIS should be issued in the second quarter of 2002. (Trapp, KY)

**Sierra Pacific Power Co.** – *Piñon Pine IGCC Power Project.* The project ended January 1, 2001. Sierra submitted the Final Technical Report to DOE. Integrated operation of the gasifier, hot gas cleanup system, and gas turbine had not been achieved when the project ended. Because the state of Nevada repealed electric deregulation and placed a moratorium on the sale of power plants in the state, the pending sale of Sierra's Tracy Station (which includes the Piñon Pine plant) to WPS Power Development, Inc., was suspended. Successes in the project included operation of the combined-cycle portion of the plant at 98 percent availability, efficient removal (by the hot gas filter) of particulates from the dirty gas, and production of good quality syngas for over 30 hours since the first syngas was produced in January 1998. DOE is preparing a post-project assessment. (Reno, NV)

**Tampa Electric Co.** – *Tampa Electric Integrated Gasification Combined-Cycle Project.* Tampa's Polk Power Station completed its operational period at the end of October 2001 with over four and one-half years of successful commercial operation. The final report is in preparation and should be published in the second quarter of 2002. (Mulberry, FL)

**Alaska Industrial Development and Export Authority (AIDEA)** – *Healy Clean Coal Project.* Demonstration operation under the Cooperative Agreement was completed in December 1999. The Final Report was approved and issued for public release. The Final Report, as well as copies of all the Topical Reports describing the

key technical activities carried out during the project's two years of demonstration operations, are available on the Clean Coal Technology Compendium at <http://www.lanl.gov/projects/cctc/>. As the result of a settlement reached in March 2000, AIDEA turned the plant over to Golden Valley Electric Association, Inc. for custodial care. Financing for a "full retrofit" to a conventional low-NO<sub>x</sub> burner and lime spray dryer emission control system must be obtained if the plant is to operate in the future. There are no potential purchasers of the power other than Golden Valley. Low-interest federal loan funds to finance the "full retrofit" and refinance the existing debt on the Healy Clean Coal Project are currently being sought by Golden Valley in cooperation with AIDEA. (Healy, AK)

**Arthur D. Little, Inc.** – *Clean Coal Diesel Project*. A fuel mixture (solid loadings and additives) has been determined. Combustion testing of the fuel will commence this quarter. Hardened parts have been manufactured and will be installed after combustion tests have been accomplished. Only minor problems have been encountered. (Fairbanks, AK)

## COAL PROCESSING FOR CLEAN FUELS

**Western SynCoal LLC (formerly Rosebud SynCoal® Partnership)** – *Advanced Coal Conversion Process (ACCP) Demonstration*. The ACCP Demonstration Project in Colstrip, Montana, has processed over 2.9 million tons of raw subbituminous coal. Nearly 2 million tons has been supplied to customers, including industries (primarily cement and lime plants) and utilities. Montana Power agreed in September 2000 to sell its coal businesses, including Western SynCoal LLC, to Westmoreland Mining LLC. Because Westmoreland cannot take advantage of synthetic fuel

production tax credits due to their current tax status, operation of the ACCP is not economical under their ownership. Therefore, operations at the ACCP facility have been suspended. Westmoreland is continuing to seek opportunities to sell the ACCP plant to parties that can use the synthetic fuel production tax advantages so operations potentially could be restarted. (Colstrip, MT)

**Air Products Liquid Phase Conversion Company, L.P.** – *Commercial-Scale Demonstration of the Liquid Phase Methanol Process*. The Liquid Phase Methanol (LPMEOH™) Process Demonstration Facility continues to experience stable operation on coal-derived synthesis gas. The catalyst guard bed adsorbent was replaced in April 2001. The fresh adsorbent was chemically reduced with dilute synthesis gas and placed into service. In August 2001, a successful *in-situ* activation of a full charge of methanol synthesis catalyst, over 40,000 pounds, was completed in the LPMEOH™ reactor. Since being restarted with fresh catalyst in December 1997, the demonstration facility has approached 99 percent availability, and since April 1997, the facility has produced over 80 million gallons of methanol, all of which was accepted by Eastman Chemical Company for use in downstream chemical processes. Monitoring all potential catalyst poisons, and methods for their removal and control, continue to be important. (Kingsport, TN)

## INDUSTRIAL APPLICATIONS

**CPICOR Management Company, L.L.C.** – *Clean Power From Integrated Coal/Ore Reduction*. DOE has continued its work toward an Environmental Impact Statement for this project, a draft of which is expected later in 2002. The CPICOR Management Company (CMC) continues to perform baseline environmental moni-

toring and preliminary engineering and design. CMC also continues to work closely with the Australian developers of the Hismelt Process and iron/steel engineering firms to establish a process and mechanical design database for this project. This project will be designed to produce 3,300 tons per day of liquid iron and approximately 160 MWe from the by-product gases. CMC is discussing teaming arrangements with several engineering and independent power producers. (Vineyard, UT)

**ThermoChem, Inc.** – *Pulse Combustor Design Qualification Test*. The Public Design Review for the Pulse Combustor is being developed. The Final Report is expected to be submitted to DOE in the near future. A no-cost time extension extends the Cooperative Agreement to March 31, 2002. (Baltimore, MD)

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**FE-24**

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